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Research Article

Management of Rice Grain Discoloration Complex with The Use of Medicinal Plant Extracts and New Generation Fungicides Under Guyana Agricultural Settings

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Abstract

Rice Grain Discolouration (GD) is caused by a complex group of microorganisms. It is an emerging condition capable of causing significant reduction in the quality and quantity of paddy produce in Guyana. The symptoms of GD were observed on all the popular rice cultivar cultivated by the Guyanese farmers. The higher incidence of GD was reported by rice farmers, millers, exporters and other stakeholder in the rice industry in Guyana, may be due to the rapid changes in the climatic conditions, thereby resulted in the increasing of the aggressiveness of the once minor pathogen(s) to devastate the rice industry. During the investigation, management of the GD condition was the main focus using aqueous extracts of medicinal plant and new generation type of fungicides to reduce the disease condition from affecting rice production in the country. The research found treatment with extracts of Black sage plant (Cordia curassavica) at 15%; Bael tree (Aegle marmelos) at 15%; Madar plant (Calotropis gigantea, C. procera) at 15%; Thick leaf thyme (Thymus vulgaris) at 15% and Neem (Azadirachta indica) at 15% along fungicidal treatment with Saaf 75WP (Mancozem 63%, Carbendazim 12%) at 300 to 500, g/ac., Rodazim 50SC (Carbendazim 50%) at 300 ml/ac., Glory 75WG (Mancozeb + Azoxystrobin) at 600g/ac., Antracol 70WP (Propineb) at 500g/ac, Carbendazim 50SC (Carbendazim 50%) at 300 ml/ac. and Fugi One (Isoprothiolane 40% SC) at 300 ml/ac. demonstrated significant reduction in grain discolouration incidence ranging from 33.54 to 75.06 percent during the spring and autumn seasons of 2020 and 2021. Additionally, these treatments showed favorable influence in terms of plant growth, yield parameters and grain yield responses. Therefore, these treatment at their respective rates of application can be recommended as a protective treatment for managing the GD conditions.

Keywords: Rice; Grain Discolouration; Medicinal plant extracts; Fungicides; Management

Introduction

Rice (Oryza sativa L.) is an important cereal crop cultivated in many parts of the world [1]. It is one of the largest users of agri cultural land in Guyana with more that 92,000 ha. being double cropped annually with an average productivity lay between 5.7 to

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6.5 t/ha within the different geographical area. Rice contributes more than 22.5% to Guyana agricultural GDP and employment for more than 12% of the Guyanese population directly and indirectly [2]. The rice crop is known to be challenged by many pests and disease. Rice Grain Discoloration (GD) has been one of them that have be on the increase in recent times not only in Guyana, but at a global level causing great reduction in quality and quantity of grains produced [3]. The GD condition was reported by more that 30% of the rice farmers and 75% of the rice millers and exporters [4]. This GD condition have been observed to be on an increase in some of the most popular cultivars under cultivation in Guyana like the GRDB 10, 11, 12, 13, 14 and 15 [5]. This grain discoloration condition often referred to by farmers and millers as 'black-tip'. It is a dark, small imperfection that occurs on the dorsal surface (the surface opposite the germ) of rice kernels and has a lesion-like appearance that is unlikely to be detected in the field [4,5]. This grain discoloration condition usually causes the grade of paddy to be lowered, resulted in great losses to the farmers. The GD condition is caused by a pathogen complex and was reported from few places of India [6]. Similar observations were reported by many researchers in many other parts of the world where rice have been cultivated [3,4] [7]. reported that eight pathogens namely *Bipolaris oryzae*, *Alternaria alternata*, *Alternaria padwickii, Drechslera oryzae, Fusarium moniliforme, Curvularia oryzae, Nigrospora oryzae and Aspergillus* niger were isolated from seed samples with grain discolouration diseased collected from rice areas of NIAB, Faisalabad, Sheikhupura, Samundri, PirMahal and Vehari [8]. reported that the field fungi such as Drechslera oryzae, Curvularia lunata and Fusarium moniliforme were predominantly associated with the grain discolouration in rice. Likewise, in Guyana [4]. reported that Curvularia spp. to be the most predominant fungal pathogen associated with greater than 95% of the sample observed with signs and symptoms of grain discolouration. Additionally, the presence of *Bipolaris oryzae*, *Sarocladium oryzae*, *Alternaria spp., Aspergillus spp.* and *Fusarium spp*. was were detected at low levels below 5% of the samples. Subsequently the Centre for Agriculture and Biosciences International (CABI) of the UK has confirmed the pathogen as Curvularia lunata, based on the amplification and sequence analysis of Internal Transcribed Spacer (ITS) region of the rDNA. As such, this experiment was design with the aims to find the most effective management options for the grain discolouration ('black-tip') condition within the rice industry in Guyana. In view of this, five plant extracts with anti-microbial properties and seven novel fungicides were evaluated against the pathogens causing grain discolouration under Guyana rice cultivation system

Material And Methods

Preparation of plant extracts

Healthy and fresh medicinal plants samples of five different plants species viz. Black sage plant (Cordia curassavica); Bael tree (Aegle marmelos); Madar plant (Calotropis gigantea, C. procera); Thick leaf thyme (Thymus vulgaris) and Neem (Azadirachta indica) were collected from surrounding areas of the GRDB, RRS, Burma in region number 5 (Mahaica-Abary), Guyana. These plant samples collected were carefully labelled and transferred to the Laboratory of Plant Pathology Department, RRS, Burma. The plant samples were washed with running tap water and then rinsed two times with sterile distilled water and left in the preparation area to air dry for 2 to 3 hours. The selected plant parts were cut into small pieces (1-3 cm) and 1,000 gram of plant tissue mixed 1,000 ml sterile distilled water (1:1 W/V) was then ground using a heavy duty electrical commercial laboratory blender. The ground samples were filtered through a double layered white muslin cloth into a beaker. The filtrate that constituted 100% concentration was collected and stored in a sterile conical flask at 25-28°C for further use in the study (13).

Isolation of the grain discolouration microorganism complex

Paddy samples with and without grain discolouration symptoms were collected randomly from farmers' fields surrounding the GRDB, RRS at Burma in region # 5 (Mahaica-Berbice) and taken to the Laboratory of the Plant Pathology department at GRDB, RRS, Burma. The samples collected were analyzed using the blotter test and agar plate method as described in (14) and (15). The standard protocol of International Seed Testing Association (16) and International Rice Research Institute (IRRI) was followed to detect and identify signs of fruiting bodies of the fungal microorganism complex. The isolation of the microorganism of interest (*C. lunata, B. oryzae, S. oryzae, Fusarium sp., Alternaria sp., Aspergillus sp*.) was done following the procedure as describe by [4]. The microorganisms complex of interest was identified using temporary microscopic slides prepared from mycelium/ spores emerged from the seeds plated into PDA prepared petri plates. The spores observed were further isolated using single spore isolation technique. The pathogenicity test was carried out following the Koch's postulates following the protocol as describe by [4]. The most aggressive isolates of the pathogens were mass multiplied and stored at - 4°C for use as inoculum in the current study.

Application of plant extracts and fungicides treatment under in vivo

Individual treatments of plant extracts viz. Black sage plant (Cordia curassavica); Bael tree (Aegle marmelos); Madar plant (Calotropis gigantea, C. procera); Thick leaf thyme (Thymus vulgaris) and Neem (Azadirachta indica) each at 15% concentration and each new fungicides treatment viz. Saaf 75WP (Mancozem 63%, Carbendazim 12%) at 300, 500, 700 and 900 g/ac., Rodazim 50SC (Carbendazim 50%) at 300 ml/ac., Amistar Xtra 28SC (Triazol, Estrobilurtina., Cyproconazol, Azoxystrobin) at 300 ml/ac., Glory 75WG (Mancozeb + Azoxystrobin) at 600g/ac., Antracol 70WP (Propineb) at 500g/ac, Carbendazim 50SC (Carbendazim 50%) at 300 ml/ac. and Fugi One (Isoprothiolane 40% SC) at 300 ml/ac were keenly calculated, weight/measured out and applied as foliar spray using Cooper Pegler (CP3) manual operated knapsack sprayer with a built in pressure relief valve at 62 and 70 Days After

Sowing (DAS). The plots that did not receive plant extract or fungicides serves as untreated control. The uniform spray was ensured by covering both surface of entire plant with minute droplets of the solution.

Field evaluation of plant extracts and fungicides against grain discoloration complex

Field experiments was conducted during the first (spring) crop and second(autumn) crop of 2020 and repeated both season of [5]. Plant Pathology experimental area at the RRS, Burma, Mahaicony, East Coast Demerara. The rice cultivars GRDB 10, GRDB 14 and GRDB 15 were used in this study. The field design laid out using Randomized Complete Block Design (RCBD), with four replications per each treatment as in 2.3. The crop was raised by direct seeded method using a seed rate of 180 lbs/ ac. with an individual plot size of 3 m X 5 m (15 m^2). The fertilizer was applied at the rate of N_{120} P_{50} K_{10} Kg/ha at recommended stages of crop growth. The standard agronomic practices were followed throughout the cropping period. The experiment was inoculated with microorganism complex of interest [predominantly Curvularia lunata at 95% concentration level and the others between 3-5% of the spore concentration] with spore suspension concentration of 10^5 grown in the laboratory at 45, 50 and 55 DAS. The treatments were applied 7 days after inoculation. These treatments were applied as foliar spray two times at an interval of 7-10 days. The control was also sprayed with distilled water.

Assessment of growth parameters, yield attributes, grain yield and grain discoloration incidence

The impact of treatments on growth parameters was assessed by measuring the plant height and counting the number of tillers per square meter at harvesting time. The yield attributes were derived by measuring the panicle length, counting the number of filled and unfilled grains per panicle, weight the 1000-grain from 10 panicles harvested from each individual plots. The total grain yield was assessed after harvest by threshing and recording the weight and moisture from each plot. From the assessment of the grain discolouration incidence the panicle harvested from each plot 100 grains were selected randomly and shelled manually, as well as 100 grams from the samples harvested was weighed and shelled to assessed the percent grain discoloration incidence.

Statistical data analysis and computations

The data obtained from various field experiments were analyzed using the RCBD statistical methods. The ANOVA and statistical significance were obtained using the Statistix 8.0 analytical software and graphs were derived using Microsoft Excel Software, Windows 10. Also, percent change in grain discoloration incidence, growth parameters, yield parameters over control were calculated using the following formula: Percent change= (T-C/C)*100; Where C= Value of control, T= Value of treatment.

Results

Efficacy of plant extracts and fungicides against grain discolouration incidence-2020

During the two cropping seasons of 2020 five (5) medicinal plant extracts and seven (7) fungicides were evaluated at various rates for their effectiveness against grain discolouration (GD). In the spring crop, 2020 all treatment showed significantly lower percent incidence of grain discolouration as compared to the untreated control (Table 1). Treatments with extract from Madar plant (15%) and Neem (15%) showed greater that 45.00 percent reduction in incidence of grain discolouration, followed by Black sage and Bale tree extracts (42.01 and 41.73% reduction in GD incidence, respectively). Similarly, treatment with Carbendazim 50 SC at 300ml/ac; Saaf 75WP at 300 and 500g/ac showed greater than 42% reduction in GD incidence (Table 1). Likewise, during the autumn crop 2020 all treatment application demonstrated significantly lower percent incidence of grain discolouration, with reduction in incidence of grain discolouration ranging from 35.39 to 60.07 percent over the untreated control (Table 1). The highest percentage incidence of grain discolouration was observed to be that of the control during both seasons (16.50% and 15.73%, respectively (Table 1).

Table 1: Effect of plant extracts and fungicides on the incidence of grain discolouration during spring and autumn, 2020.

Chemicals	Rates	Percent incidence of grain discolouration		Percent reduction in grain discolouration incidence over control	
		*Spring, 2020	*Autumn, 2020	*Spring, 2020	*Autumn, 2020
Black sage	15%	9.57 B	6.48 D	-42.01	-58.82
Bael tree extract	15%	9.62 B	6.50 D	-41.73	-58.70
Madar plant	15%	8.96 B	8.67 BCD	-45.71	-44.86
Thick leaf thyme	15%	10.17 B	7.96 BCD	-38.39	-49.37
Neem	15%	9.00 B	6.79 CD	-45.48	-56.83
Saaf 75 WP	300g/ac	9.43 B	10.16 B	-42.86	-35.39
Saaf 75 WP	500g/ac	9.43 B	8.20 BCD	-42.84	-47.86
Saaf 75 WP	700g/ac	10.26 B	8.63 BCD	-37.81	-45.15

Saaf 75 WP	900g/ac	+	7.32 CD	+	-53.45
Rodazim 50 SC	300ml/ac	10.86 B	6.28 D	-34.19	-60.07
Amistar Xtra 28 SC	300ml/ac	10.72 B	6.58 CD	-35.06	-58.16
Glory 75 WG	600g/ac	10.27 B	7.26 CD	-37.75	-53.82
Antracol 70WP	500g/ac	10.33 B	8.02 BCD	-37.39	-49.04
Carbendazim 50SC	300ml/ac	9.21 B	7.38 CD	-44.17	-53.10
Fugione (Check)	300ml/ac	10.46 B	8.99 BC	-36.62	-42.83
Control (Distill water)	-	16.50 A	15.73 A	0.00	0.00
General Mean		10.32	8.18		
SEm ±		1.20	1.22		
CD (P = 0.05)		2.46	2.46		
CV (%)		14.22	21.13		

* = average of four replication; += No evaluation was done.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Efficacy of plant extracts and fungicides against grain discolouration incidence-2021

This experiment was repeated over the two cropping seasons of 2021. Similarly, during the spring crop, 2021 all treatment showed significantly lower percent incidence of grain discolouration as compared to the untreated control (Table 2, Figure 1). Treatments with plant extract at 15 % concentration viz. Bael tree extract showed 74.39% reduction in grain discolouration incidence, followed by Thick leaf thyme extract (62.18%), Neem tree extract (59.58%), Black sage plant extract (54.63%) and Madar plant (54.53%) expressed a higher reduction in GD incidence, respectively (Table 2).

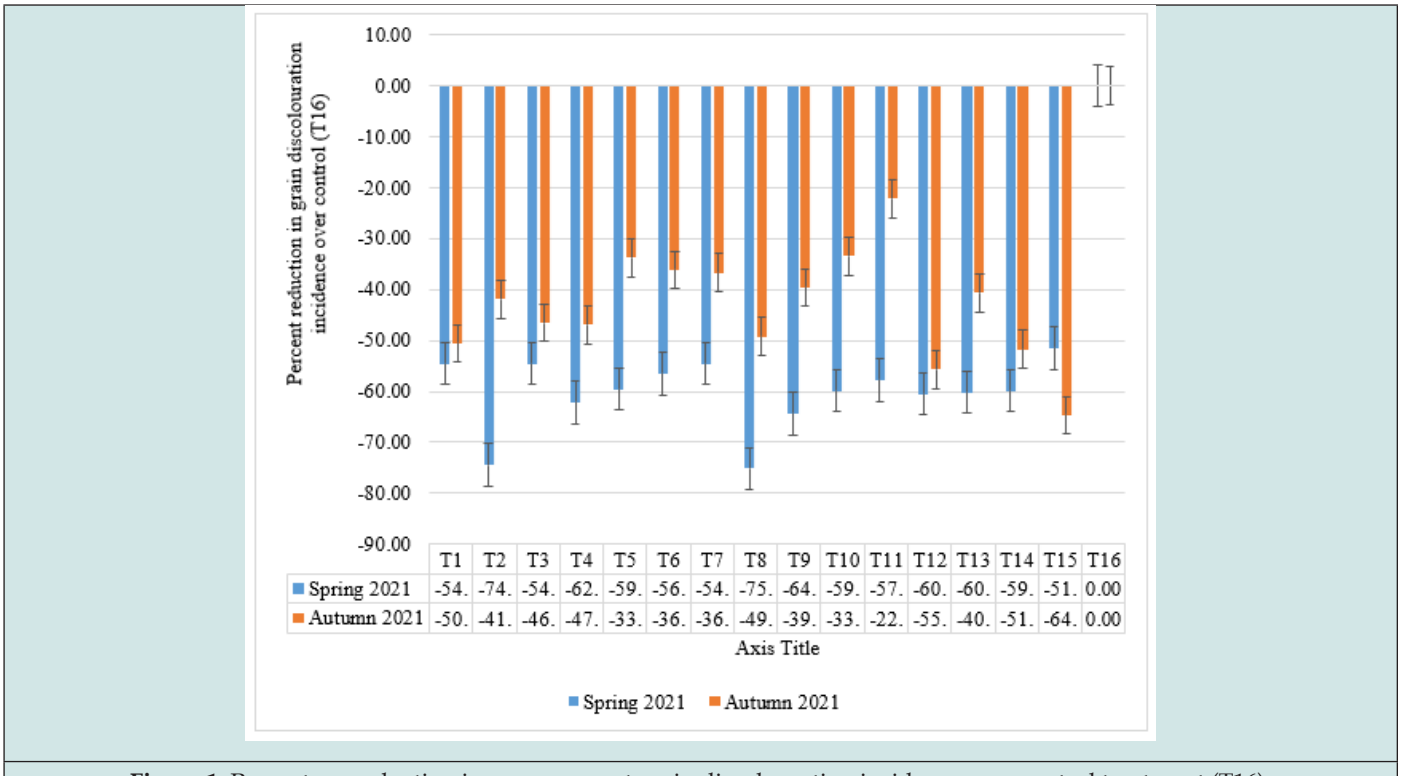

Figure 1: Percentage reduction in mean percent grain discolouration incidence over control treatment (T16).

Table 2: Effect of plant extracts and fungicides on the incidence of grain discolouration during spring and autumn, 2021.

Trt.	Chemicals	Rates	Percent incidence of grain discolouration	Percent reduction in grain discolouration incidence over control		
			*Spring, 2021	*Autumn, 2021	*Spring, 2021	*Autumn, 2021
T1	Black sage	15%	9.07 B	4.70 CD	-54.63	-50.58
T2	Bael tree extract	15%	5.12 B	5.52 BCD	-74.39	-41.96
T3	Madar plant	15%	9.09 B	5.08 BCD	-54.53	-46.58
T4	Thick leaf thyme	15%	7.56 B	5.04 BCD	-62.18	-47.00
T5	Neem	15%	8.08 B	6.29 BC	-59.58	-33.86
T6	Saaf 75 WP	300g/ac	8.69 B	6.07 BC	-56.53	-36.17
T7	Saaf 75 WP	500g/ac	9.08 B	6.02 BC	-54.58	-36.70
T8	Saaf 75 WP	700g/ac	4.98 B	4.83 BCD	-75.09	-49.21
T9	Saaf 75 WP	900g/ac	7.13 B	5.74 BCD	-64.33	-39.64
T10	Rodazim 50 SC	300ml/ac	8.01 B	6.32 BC	-59.93	-33.54
T11	Amistar Xtra 28 SC	300ml/ac	8.44 B	7.39 AB	-57.78	-22.29
T12	Glory 75 WG	600g/ac	7.90 B	4.21 CD	-60.48	-55.73
T13	Antracol 70WP	500g/ac	7.96 B	5.64 BCD	-60.18	-40.69
T14	Carbenda-zim 50SC	300ml/ac	8.01 B	4.59 CD	-59.93	-51.74
T15	Fugione (Check)	300ml/ac	9.69 B	3.36 D	-51.53	-64.67
T16	Control (water)	-	19.99 A	9.51 A	0.00	0.00
General Mean			8.67	5.64		
SEm ±			2.89	1.29		
CD (P = 0.05)			5.83	2.60		
CV (%)			47.16	32.31		

* = average of four replication;

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Efficacy of plant extracts and fungicides against grain discolouration incidence-2021

This experiment was repeated over the two cropping seasons of 2021. Similarly, during the spring crop, 2021 all treatment showed significantly lower percent incidence of grain discolouration as compared to the untreated control (Table 2, Figure 1). Treatments with plant extract at 15 % concentration viz. Bael tree extract showed 74.39% reduction in grain discolouration incidence, followed by Thick leaf thyme extract (62.18%), Neem tree extract (59.58%), Black sage plant extract (54.63%) and Madar plant (54.53%) expressed a higher reduction in GD incidence, respectively (Table 2).

Likewise, the treatments with fungicides viz. Saaf 75WP (at all rates), Rodazim 50 SC , Amistar Xtra 28 SC , Carbendazim 50 SC and Fugione (Check at 300ml/ac, respectively along with Glory 75 WG and Antracol 70WP at 600 and 500g/ac, respectively demonstrated a significant reduction in GD incidence ranging from 51.53% to 75.03% during the spring crop 2021 (Table 2, Figure 1).

Likewise, during the autumn crop 2021 all treatment application demonstrated significantly lower percent incidence of grain discolouration, with reduction in incidence of grain discolouration ranging from 22.29 to 64.67 percent over the untreated control (Table 2, Figure 1). The highest percentage incidence of grain discolouration was observed to be that of the control during both seasons (19.99% and 9.51%, respectively (Table 2).

Effect of treatments on growth and grain yield parameters – spring crop 2020

Data analysis of agronomic and grain yield parameters revealed that plants treated with Saaf at 700g/ac had significantly longer panicles (31.37cm) and there was no significant difference among other treatments with regards to this parameter (Table 3). There was however no significant difference among treatments in the number of filled grains per panicle. A significantly larger number of unfilled grains per panicle were obtained from plants treated with Neem (42), followed by Glory (37) and the control (37); while treatments with Saaf at 300ml/ac produced a significantly smaller number of unfilled grains (21) (Table 3). With regards to 1,000 grain weight per treatment, plants treated with Rodazim at 300ml/ac was found to have among the heaviest grains (27.30g) along with Saaf at 700g/ac (27.37g), Glory (27.13g), Carbendazim (27.23g) and the control (26.90g). Plant height ranged from 101.3 in the untreated control to 96.23 in treatment with Saaf at 300g/ac. No significant difference was observed among other treatments with regards to plant height. The untreated control was also observed to have recorded a significantly larger number of tillers/m^2 (392) along with Saaf at 300g/ac (396) as compared to other treatments. Other treatments to have a larger number of tillers were Amistar Xtra at 300ml/ac (384), Saaf at 500 and 700g/ac (388) and Carbendazim (384), while treatments with the botanical "Madar" produced the least number of tillers (320) (Table 3).

Table 3: Effect of plant extracts and fungicides on growth parameter, yield parameter and yield during spring 2020.

Chemicals		*Growth parameters		*Yield parameters			
		[1]Plant height (cm)	Tillers/ M2	[2]Panicle Length (cm)	Av. # Filled grains/ panicle	Av. # Unfilled grains/ panicle	1000 - Grain Weight (grams)
Black sage	15%	99.13 AB	360.00 ABC	23.72 B	118.00 A	25.00 BC	24.97 AB
Bael tree extract	15%	97.63 AB	364.00 ABC	24.01 B	127.00 A	25.00 BC	25.60 AB
Madar plant	15%	97.13 AB	320.00 C	24.03 B	129.00 A	33.00 ABC	26.10 AB
Thick leaf thyme	15%	97.03 AB	368.00 ABC	24.74 B	146.00 A	33.00 ABC	26.43 AB
Neem	15%	100.87 AB	348 ABC	24.66 B	152.00 A	42.00 A	23.90 B
Saaf 75 WP	300g/ac	96.23 B	396.00 A	24.04 B	140.00 A	21.00 C	26.47 AB
Saaf 75 WP	500g/ac	96.30 B	388.00 AB	24.81 B	146.00 A	28.00 ABC	26.63 AB
Saaf 75 WP	700g/ac	98.33 AB	388.00 AB	31.37 A	159.00 A	28.00 ABC	27.30 A
Rodazim 50 SC	300ml/ac	97.37 AB	364.00 ABC	23.7 B	151.00 A	31.00 ABC	27.37 A
Amistar Xtra 28 SC	300ml/ac	98.23 AB	384.00 AB	24.16 B	125.00 A	30.00 ABC	27.27 A
Glory 75 WG	600g/ac	97.20 AB	368.00 ABC	25.89 B	148.00 A	37.00 AB	27.13 A
Antracol 70WP	500g/ac	99.13 AB	372.00 ABC	24.22 B	140.00 A	27.00 ABC	26.13 AB
Carbendazim 50SC	300ml/ac	97.77 AB	384.00 AB	23.95 B	160.00 A	30.00 ABC	27.23 A
Fugione (Check)	300ml/ac	97.50 AB	328.00 BC	23.92 B	150.00 A	33.00 ABC	26.43 AB
Control (Distill water)	-	101.30 A	392.00 A	24.75 B	153.00 A	37.00 ABC	26.90 A
General Mean		**98.08**	**368.00**	**24.80**	**143.00**	**31.00**	**26.39**
SEm ±		**1.67**	**5.49**	**1.86**	**154.61**	**55.41**	**1.02**
CD (P = 0.05)		**0.23**	**0.86**	**0.00**	**0.22**	**0.24**	**0.44**
CV (%)		**2.95**	**10.32**	**12.99**	**18.00**	**31.31**	**6.71**

* = average of four replication; 1= Average from ten plants per each replication; 2=Average from ten panicle per each replication.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Effect of treatments on growth and yield parameters – Autumn crop 2020

During the second crop of 2020 results indicated that both chemical fungicides and some botanicals would have produced plants with yield and parameters significantly greater than others under evaluation. The average panicle length was recorded as 28.73cm with the longest panicles coming from plants treated with Rodazim (34.58cm), followed by Saaf at 900g/ac (33.51cm) and Antracol (28.70cm); while treatment with Saaf at 300g/ac produced the shortest panicles (27.16cm) (Table 4). With regards to filled grains per panicle both treatment with botanicals plant extracts viz. Black sage extract, Neem extract (128, 124, grains per panicle, respectively) and fungicides viz. Saaf at 500g/ac and Amistar Xtra (124, 124 grains per panicle, respectively) recorded significantly larger number of filled grains per panicle. These treatments did not express no significant differences compared to the untreated control (Table 4). Other treatments which produced a larger number of grains per panicle were Saaf at 700g/ac (123), Antracol (122) and Madar extract (120) (Table 4).

Table 4: Effect of plant extracts and fungicides on growth parameter, yield parameter and yield during Autumn 2020.

Chemicals	Rates	*Growth parameters		*Yield parameters			
		[1]Plant height (cm)	Tillers/ m^2	[2]Panicle Length (cm)	Av. # Filled grains/ panicle	Av. # Unfilled grains/ panicle	1000 - Grain Weight (grams)
Black sage	15%	117.58 ABC	182.00 BC	28.37 BC	128.00 A	17.00 ABC	24.00 BCDE
Bael tree extract	15%	120.30 AB	192.00 BC	28.37 BC	118.00 ABCD	15.00 CD	21.43 EF
Madar plant	15%	114.00 C	204.00 ABC	27.72 BC	122.00 AB	12.00 D	28.63 A
Thick leaf thyme	15%	117.38 ABC	200.00 ABC	28.15 BC	110.00ABCD	14.00 BCD	25.93 ABCD
Neem	15%	121.13 A	184.00 BC	27.57 BC	124.00 A	14.00 BCD	27.35 A
Saaf 75 WP	300g/ac	117.80 ABC	188.00 BC	27.16 C	103.00 CD	15.00 BCD	26.10 ABC
Saaf 75 WP	500g/ac	118.80 AB	204.00 ABC	28.44 BC	124.00 A	16.00 BCD	21.45 EF
Saaf 75 WP	700g/ac	116.47 BC	204.00 ABC	28.28 BC	123.00 AB	17.00 ABC	27.65 A
Saaf 75 WP	900g/ac	117.85 ABC	200.00 ABC	33.51 AB	115.00 ABCD	18.00 ABC	28.65 A
Rodazim 50 SC	300ml/ac	117.50 ABC	204.00 ABC	34.58 A	119.00 ABCD	16.00 BCD	20.83 F
Amistar Xtra 28 SC	300ml/ac	121.50 A	184.00 BC	27.26 BC	124.00 A	17.00 ABD	22.63 EF
Glory 75 WG	600g/ac	119.53 AB	210.00 AB	27.62 BC	102.00 D	12.00 D	23.18 CDEF
Antracol 70WP	500g/ac	118.25 ABC	218.00 A	28.70 ABC	122.00 AB	21.00 A	22.93 DEF
Carbendazim 50SC	300ml/ac	118.58 AB	200.00 ABC	27.72 BC	121.00 ABC	18.00 AB	22.10 EF
Fugione (Check)	300ml/ac	117.33 ABC	178.00 C	28.04 BC	122.00 AB	14.00 BCD	28.78 A
Control (Distill water)	-	116.05 BC	204.00 ABC	27.64 BC	105.00 BCD	17.00 ABC	26.88 AB
General Mean		118.13	99.00	28.73	118.00	16.00	24.91
SEm ±		1.58	4.94	2.14	+	+	+
CD (P = 0.05)		4.50	14.08	3.03	+	+	+
CV (%)		2.68	10.00	14.92	10.79	20.02	8.27

* = average of four replication; [1]= Average from ten plants per each replication; [2]=Average from ten panicle per each replication; += SEm ± and CD Varies.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedures

On the other hand, treatments with Glory and black Sage at 300g/ac produced the least number of filled grains per panicle (102 and 103, respectively). The least number of unfilled grains per panicle was also recorded from both plant extract (Madar) and fungicide (Glory), both produced an average of 12 unfilled grains per panicle which was significantly lower than all other treatments (Table 4). Treatments with Antracol and Carbendazim however resulted in panicles with the largest number of unfilled grains (21 and 18 grains per panicle, respectively) (Table 4). The average weight of 1,000 grains was also recorded and treatments with Fugi One, Saaf at 700 and 900g/ac, Neem and Madar extract all produced on average significantly heavier grains (28.78, 27.65, 28.65, 28.63, 27.35g,

respectively) as compared to other treatments evaluated. Treatments with Rodazim, Carbendazim, Amistar Xtra, Saaf at 500g/ac and Bael extract produced significantly lighter grains (20.83, 22.00, 22.63, 21.45 and 21.43g, respectively when compared to the other treatments (Table 4).

Table 4: Effect of plant extracts and fungicides on growth parameter, yield parameter and yield during Autumn 2020.

Trt.	Treatment	Rates	*2Panicle Length (cm)	*Filled grains/ Panicle	*Unfilled grains/ Panicle	*1000 grain weight (g)	*1Plant Height (cm)	*Tillers/ m^2
T1	Black Sage Extract	15%	27.21 B	113.00 A	13.00 A	31.43 A	87.15 B	239.00 A
T2	Bael Tree Extract	15%	25.74 B	111.00 A	16.00 A	28.95 BC	88.45 AB	226.00 A
T3	Madar Extract	15%	26.98 B	109.00 AB	12.00 A	29.83 ABC	88.08 AB	260.00 A
T4	Broad Leaf Thyme Extract	15%	26.29 B	94.00 B	16.00 A	29.77 ABC	88.93 AB	262.00 A
T5	Neem Extract	15%	25.80 B	106.00 AB	12.00A	28.58 C	89.28 AB	236.00 A
T6	Saaf 75 WP	300g/ac	26.40 B	107.00 AB	15.00 A	30.75 AB	89.15 AB	233.00 A
T7	Saaf 75 WP	500g/ac	26.06 B	100.00 AB	13.00 A	28.90 BC	90.50 AB	260.00 A
T8	Saaf 75 WP	700g/ac	26.55 B	108.00 AB	13.00 A	29.63 ABC	88.33 AB	225.00 A
T9	Saaf 75 WP	900g/ac	26.46 B	111.00 A	15.00 A	31.20 AB	93.70 A	230.00 A
T10	Rodazim	300ml/ac	26.35 B	109.00 AB	15.00 A	30.13 ABC	90.10 AB	229.00 A
T11	Amistar Xtra	300ml/ac	33.43 A	109.00 AB	15.00 A	29.83 ABC	90.45 AB	252.00 A
T12	Glory 75 WG	600g/ac	26.66 B	103.00 AB	13.00 A	30.68 AB	92.53 AB	244.00 A
T13	Antracol 70 WP	500g/ac	26.25 B	107.00 AB	10.00 A	29.80 ABC	92.83 AB	261.00 A
T14	Carbendazim 50 SC	300ml/ac	26.52 B	107.00 AB	13.00 A	28.88 BC	91.23 AB	238.00 A
T15	Fugione (Check)	300ml/ac	27.25 B	111.00 A	13.00 A	28.40 C	92.53 AB	262.00 A
T16	Control (water)		26.66 B	108.00 AB	12.00 A	29.60 ABC	91.40 AB	271.00 A
Grand mean			26.91	106.97	13.23	29.77	90.29	245.94
SEM			2.53	8.26	2.96	1.00	3.10	24.39
CD (P=0.05)			5.10	16.65	5.95	2.01	6.24	49.13
CV (%)			13.30	10.93	31.59	4.75	4.85	14.03

* = average of four replication; 1= Average from ten plants per each replications; 2=Average from ten panicle per each replications.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

The average plant height ranged from 121.52 in plants treated with Amistar Xtra to 114cm in plants treated with Madar extract. Treatment with Neem and Bael extract Saaf at 500g/ac, Carbendazim and Glory all produced plants with heights towards the higher end of the spectrum (121.13, 120.30, 118.80, 118.58, 119.53 cm, respectively) (Table 4). With regards to the number of tiller/m^2, treatments with Antracol recorded the most (218), however there were other treatments which produced larger number of tillers/m^2, these were viz. Glory (210), Madar extract, Saaf at 500, and 700g/ac, Rodazim, Control (204 each), Thyme extract (200), Carbendazim (200) and Saaf 900g/ac (200). Treatment with Fugi One was observed to have produced the least number of tillers/m^2 (178) (Table 4).

Effect of treatments on growth and grain yield parameters – Spring crop 2021

Data analysis of agronomic and grain yield parameters revealed that plants treated with Amistar Xtra at 300ml/ac recorded significantly longest panicle. No significant difference was observed among panicles of any other treatment (Table 5). Similarly, the differences in filled and unfilled grains per panicle among treatments varied little. With regards to the number of filled grains per panicle, treatments with Saaf at 900g/ac, Bael tree extract and Fugi One were observed to have the largest number of grains per panicle (111.00 each); while treatment with the Broad Leaf Thyme extract produced the least number of grains per panicle (94.00). However, no significant difference was observed among other treatments (Table 5).

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

No significant difference was observed among the number of unfilled grains per panicle (Table 5). The tallest plants were found

to be those treated with Saaf at 900g/ac (93.70cm), while the shortest were those treated with Sage extract (87.15cm). No significant difference was observed among the plant height of other treatments nor was any significant difference observed among treatments for the number of tillers/m^2 (Table 5). With regards to 1,000 grain weight per treatment, plants treated with Black Sage Extract (15%) was found to have among the heaviest grains (31.43g), along with Saaf at 900g/ac (31.20g); Saaf at 300g/ac (30.75g), Glory (30.68g), and Rodazim (30.13g). All other treatment including the control recorded 1,000 grain weight ranging from 28.58g to 29.95g (Table 5).

Table 5: Effect of plant extracts and fungicides on growth and yield parameter during spring 2021.

Trt.	Treatment	Rates	*2Panicle Length (cm)	*Filled grains/ Panicle	*Unfilled grains/ Panicle	*1000 grain weight (g)	*1Plant Height (cm)	*Tillers/ m^2
T1	Black Sage Extract	15%	27.21 B	113.00 A	13.00 A	31.43 A	87.15 B	239.00 A
T2	Bael Tree Extract	15%	25.74 B	111.00 A	16.00 A	28.95 BC	88.45 AB	226.00 A
T3	Madar Extract	15%	26.98 B	109.00 AB	12.00 A	29.83 ABC	88.08 AB	260.00 A
T4	Broad Leaf Thyme Extract	15%	26.29 B	94.00 B	16.00 A	29.77 ABC	88.93 AB	262.00 A
T5	Neem Extract	15%	25.80 B	106.00 AB	12.00A	28.58 C	89.28 AB	236.00 A
T6	Saaf 75 WP	300g/ac	26.40 B	107.00 AB	15.00 A	30.75 AB	89.15 AB	233.00 A
T7	Saaf 75 WP	500g/ac	26.06 B	100.00 AB	13.00 A	28.90 BC	90.50 AB	260.00 A
T8	Saaf 75 WP	700g/ac	26.55 B	108.00 AB	13.00 A	29.63 ABC	88.33 AB	225.00 A
T9	Saaf 75 WP	900g/ac	26.46 B	111.00 A	15.00 A	31.20 AB	93.70 A	230.00 A
T10	Rodazim	300ml/ac	26.35 B	109.00 AB	15.00 A	30.13 ABC	90.10 AB	229.00 A
T11	Amistar Xtra	300ml/ac	33.43 A	109.00 AB	15.00 A	29.83 ABC	90.45 AB	252.00 A
T12	Glory 75 WG	600g/ac	26.66 B	103.00 AB	13.00 A	30.68 AB	92.53 AB	244.00 A
T13	Antracol 70 WP	500g/ac	26.25 B	107.00 AB	10.00 A	29.80 ABC	92.83 AB	261.00 A
T14	Carbendazim 50 SC	300ml/ac	26.52 B	107.00 AB	13.00 A	28.88 BC	91.23 AB	238.00 A
T15	Fugione (Check)	300ml/ac	27.25 B	111.00 A	13.00 A	28.40 C	92.53 AB	262.00 A
T16	Control (water)		26.66 B	108.00 AB	12.00 A	29.60 ABC	91.40 AB	271.00 A
Grand mean			26.91	106.97	13.23	29.77	90.29	245.94
SEM			2.53	8.26	2.96	1.00	3.10	24.39
CD (P=0.05)			5.10	16.65	5.95	2.01	6.24	49.13
CV (%)			13.30	10.93	31.59	4.75	4.85	14.03

* = average of four replication; 1= Average from ten plants per each replications; 2=Average from ten panicle per each replications.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Effect of treatments on growth and grain yield parameters – Autumn crop 2021

During the second crop of 2021 evaluation panicle length ranged from 28.53cm in treatments with Saaf at 300g/ac, followed by 28.44cm in treatments with Carbendazim to 26.83cm in treatments with Antracol (Table 6). The largest number of filled grains per panicle came from plants treated with Saaf at 300g/ac (146.00 grains), followed by those treated with Glory (145.00 grains) and Neem extract (140.00 grains). On the lower side of the spectrum were plants treated with Madar and Black Sage extracts (124.00 and 121.00 grains, respectively) as well as those treated with Antracol and Fugi One (check) (119 .00 and 113.00 grains, respectively). Although having among the highest number of filled grains per panicle, treatments with Glory also had the largest number of unfilled grains per panicle (30.00 grains), followed by treatments with Amistar Xtra (29.00 grains). Treatments with Saaf at 900g/ac was recorded as having the least number of unfilled grains per panicle (16.00 grains), followed by treatments with Madar, Bael and Saaf at 300g/ac (17.00, 18.00 and ,18.00 grains, respectively). While plants treated with some fungicides and botanicals produced large number of filled grains per panicle, the heaviest 1,000 grain weight was observed to have come from the untreated control which recorded 29.30g, followed by treatments with Carbendazim (28.93g) and Saaf at 300g/ac (28.73g). Treatments with Amistar Xtra and Glory weighed the least (27.30g and 27.13g, respectively) (Table 6).

No significant difference was observed among the heights of plants within this trial; however plots treated with Bael tree extract produced the largest number of tillers/m^2(276.00), followed by

treatments with Glory (268.00) and Amistar Xtra (264.00). Treatments with Broad leaf thyme, Sage and Madar extract produced the least number of tillers/m^2 (187.00, 185.00 and 172.00 tillers/m^2, respectively) (Table 6).

Table 6: Effect of fungicides on growth parameter, yield parameter and yield during autumn 2021.

Trt	Treatment	Rates	*2Panicle Length (cm)	*Filled grains/ Panicle	*Unfilled grains/ Panicle	*1000 grain weight (g)	*1Plant Height (cm)	*Tillers/ m^2
T1	Black Sage Extract	15%	27.79 ABC	121.00 CDE	26.00 ABC	27.50 BCD	109.53 A	185.00 BC
T2	Bael Tree Extract	15%	27.62 ABC	126.00 ABCDE	18.00 CD	28.00 ABCD	109.15 A	276.00 A
T3	Madar Extract	15%	27.93 ABC	124.00 CDE	17.00 CD	28.40 ABCD	108.75 A	172.00 C
T4	Broad Leaf Thyme Extract	15%	27.73 ABC	133.00 ABCDE	25.00 ABCD	27.98 ABCD	107.15 A	187.00 BC
T5	Neem Extract	15%	27.60 ABC	140 ABC	23.00 ABCD	27.60 BCD	108.92 A	229.00 ABC
T6	Saaf 75 WP	300g/ac	28.53 A	146.00 A	18.00 CD	28.73 ABC	109.80 A	255.00 ABC
T7	Saaf 75 WP	500g/ac	27.76 ABC	127.00 ABCDE	21.00 ABCD	28.58 ABCD	108.72 A	197.00 ABC
T8	Saaf 75 WP	700g/ac	27.59 ABC	133.00 ABCDE	21.00 BCD	28.08 ABCD	111.00 A	242.00 ABC
T9	Saaf 75 WP	900g/ac	27.41 ABC	125.00 BCDE	16.00 D	27.48 BCD	108.00 A	197.00 ABC
T10	Rodazim	300ml/ac	27.14 BC	125.00 BCDE	22.00 ABCD	28.30 ABCD	110.25 A	242.00 ABC
T11	Amistar Xtra	300ml/ac	26.81 C	128.00 ABCDE	29.00 AB	27.30 CD	107.65 A	264.00 AB
T12	Glory 75 WG	600g/ac	27.07 BC	145.00 AB	30.00 A	27.13 D	107.85 A	268.00 AB
T13	Antracol 70 WP	500g/ac	26.83 C	119.00 DE	20.00 BCD	27.50 BCD	105.45 A	225.00 ABC
T14	Carbendazim 50 SC	300ml/ac	28.44 A	133.00 ABCD	19.00 BCD	28.93 AB	105.85 A	224.00 ABC
T15	Fugione (Check)	300ml/ac	27.36 ABC	113.00 E	25.00 ABCD	27.15 CD	105.25 A	205.00 ABC
T16	Control (water)		28.22 AB	131.00 ABCDE	21.00 ABCD	29.30 A	106.03 A	221.00 ABC
Grand mean			27.61	129.00	22.00	28.00	108.08	224.00
SEM			0.60	7.02	4.85	0.78	3.36	44.12
CD (P=0.05)			1.20	20.00	9.77	1.58	6.77	88.87
CV (%)			3.06	10.87	31.27	3.96	4.40	27.82

* = average of four replication; 1= Average from ten plants per each replication; 2=Average from ten panicle per each replication

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Effect of treatments on grain yield during 1st and 2nd Crop 2020

An evaluation of the grain yield during the spring of 2020 indicated treatments with Saaf at 700g/ac yielded significantly higher yields (6417.10kg/ha) as compared to other treatments, followed by treatments with Glory 600g/ac and Saaf at 300g/ac which yielded 5736.10 and 5644.20kg/ha, respectively (Table 7).

Table 7: Effects of plant extract and fungicides against grain discolouration on grain yield during 1st and 2nd Crop 2020.

Treatment	Rates	*Grain Yield			
		1st Crop 2020		2nd Crop 2020	
		Kg/ ha.	Bags/ ac.	Kg/ ha.	Bags/ ac.
Black sage	15%	5018.70 BCD	31.91 BCD	4518.90 AB	28.74 AB
Bael tree extract	15%	4909.90 CD	31.22 CD	4666.20 AB	29.67 AB
Madar plant	15%	5329.30 BCD	33.89 BCD	4842.40 AB	30.80 AB
Thick leaf thyme	15%	4973.00 BCD	31.63 BCD	5084.40 AB	32.33 AB
Neem	15%	5256.00 BCD	33.43 BCD	4438.90 AB	28.23 AB
Saaf 75 WP	300g/ac	5644.20 ABC	35.89 ABC	4297.00 B	27.33 B
Saaf 75 WP	500g/ac	5137.90 BCD	32.68 BCD	4942.30 AB	31.43 AB
Saaf 75 WP	700g/ac	6417.10 A	40.81 A	4684.90 AB	29.79 AB

Saaf 75 WP	900g/ac	-	-	5114.10 AB	32.52 AB
Rodazim 50 SC	300ml/ac	5133.60 BCD	32.65 BCD	5267.60 A	33.50 A
Amistar Xtra 28 SC	300ml/ac	5287.20 BCD	33.63 BCD	4493.80 AB	28.58 AB
Glory 75 WG	600g/ac	5736.10 A	36.48 AB	5031.50 AB	32.00 AB
Antracol 70WP	500g/ac	5212.70 BCD	33.15 BCD	4724.50 AB	30.05 AB
Carbendazim 50SC	300ml/ac	5185.80 BCD	32.97 BCD	5077.00 AB	32.28 AB
Fugione (Check)	300ml/ac	5538.80 BC	35.22 BC	5244.60 A	33.35 A
Control (Distill water)	-	4693.80 D	29.85 D	5143.90 A	32.71 A
General Mean		**5298.30**	**33.69**	**4848.20**	**30.83**
SEm ±		**284.40**	**1.81**	**294.78**	**1.88**
CD (P = 0.05)		**0.57**	**0.57**	**416.88**	**2.65**
CV (%)		**9.30**	**9.30**	**12.16**	**12.16**

* = average of four replication

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedures.

However, during the autumn crop of 2020, treatments with Rodazim, Fugi One and the untreated control recorded higher yield as compared to other treatments (5267.60, 5244.60 and 5143.90kg/ha, respectively); while treatment with Saaf at 300g/ac yielded the least; 4297.00kg/ha. There was no significant difference among the yield of other treatments evaluated (Table 7).

Effect of treatments on grain yield during 1st and 2nd Crop 2021

An evaluation of the grain yield during the spring of 2021 indicated plot yield was highest in those treated with Saaf at 300 and 700g/ac (5672.80 and 5508.00 kg/ha, respectively), yield which were significantly lower were Madar extract (4592.8.00 kg/ha), Saaf at 500g/ac (4586.70 kg/ha) and Glory at 600g/ac (4074.8.00kg/ha) (Table 8). Likewise, plots treated with the fungicide Amistar Xtra gave the highest total grain yield as compared to other treatments (4899.40 kg/ha). This was followed by treatment with Neem extract (4491.70kg/ha), the untreated control (4284.90kg/ha) and Rodazim (3989.70kg/ha). Bael tree extract and Antracol yielded during this trial (3383.30kg/ha and 3318.10kg/ha respectively) (Table 8).

Table 8: Effects of plant extract and fungicides against grain discolouration on yield during spring and autumn crop 2021.

Trt.	Treatment	Rates	*Spring, 2021		*Autumn, 2021	
			Kg/ha	Bags/ac	Kg/ha	Bags/ac
T1	Black Sage Extract	15%	5057.00 ABC	32.16 ABC	3660.30 BC	23.30 BC
T2	Bael Tree Extract	15%	4778.00 BCD	30.39 BCD	4128.90 ABC	26.30 ABC
T3	Madar Extract	15%	4592.60 CD	29.21 CD	3383.30 C	21.50 C
T4	Broad Leaf Thyme Extract	15%	4982.50 ABC	31.69 ABC	3798.90 BC	24.20 BC
T5	Neem Extract	15%	5029.90 ABC	31.99 ABC	4491.70 AB	28.6 AB
T6	Saaf 75 WP	300g/ac	5672.80 A	36.08 A	4002.20 ABC	25.50 ABC
T7	Saaf 75 WP	500g/ac	4586.70 CD	29.17 CD	3519.10 BC	22.40 BC
T8	Saaf 75 WP	700g/ac	5508.00 AB	35.03 AB	3817.00 BC	24.30 BC
T9	Saaf 75 WP	900g/ac	5353.60 ABC	34.05 ABC	3659.70 BC	23.30 BC
T10	Rodazim	300ml/ac	5058.70 ABC	32.17 ABC	3989.70 ABC	25.40 ABC
T11	Amistar Xtra	300ml/ac	5393.50 ABC	34.30 ABC	4899.40 A	31.20 A
T12	Glory 75 WG	600g/ac	4074.80 D	25.91 D	3836.50 BC	24.40 BC
T13	Antracol 70 WP	500g/ac	5370.90 ABC	34.16 ABC	3318.10 C	21.10 C
T14	Carbendazim 50 SC	300ml/ac	5040.90 ABC	32.06 ABC	3727.80 BC	23.70 BC
T15	Fugione (Check)	300ml/ac	5108.20 ABC	32.49 ABC	3561.70 BC	22.60 BC

T16	Control (water)		5296.30 ABC	33.68 ABC	4284.90 ABC	27.30 ABC
Grand mean			5056.50	32.16	3879.90	24.67
SEM			401.81	2.56	515.49	3.27
CD (P=0.05)			809.28	5.15	1038.30	6.59
CV (%)			11.24	11.24	18.79	18.76

* = average of four replication

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedures.

Means values in columns followed by same letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedures.

Notes (Figure 2 and 3): T1- Black sage (15%); T2- Bale tree (15%); T3- Madar plant (15%); T4- Thick leaf thyme (15%); T5- Neem (15%); T6- Saaf 75 WP (300 g/ac.); T7- Saaf 75 WP (500 g/ac.); T8- Saaf 75 WP (7000 g/ac.); T9- Saaf 75 WP (900 g/ac.); T10- Rodazim 50 SC (300 g/ac.); T11- Amistar Xtra 28 SC (300 g/ac.); T12- Glory 75 WG (600 g/ac.); T13- Antracol 70WP(500g/ac); T14- Carbendazim 50 SC (300 g/ac.); T15- Fugi-One (Check (300 ml/ac.); T16- Untreated control.

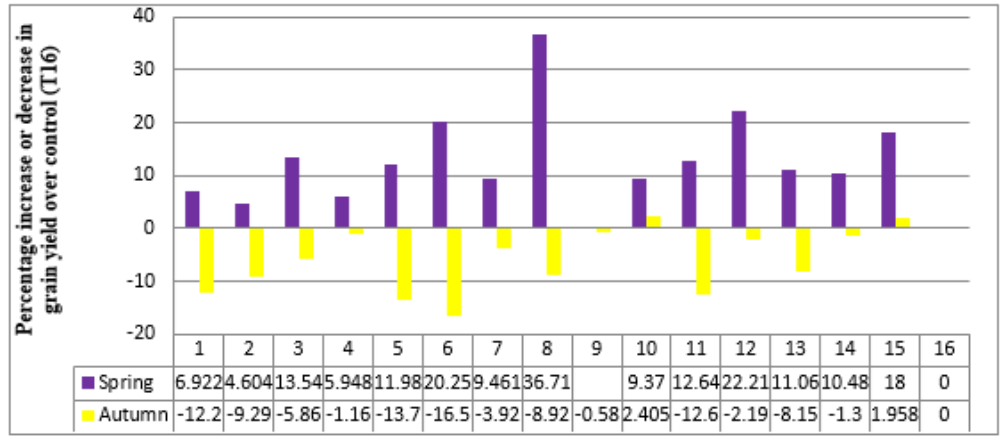

Figure 2: Percentage increase or decrease in grain yield over the untreated control (T16) Spring and Autumn 2020.

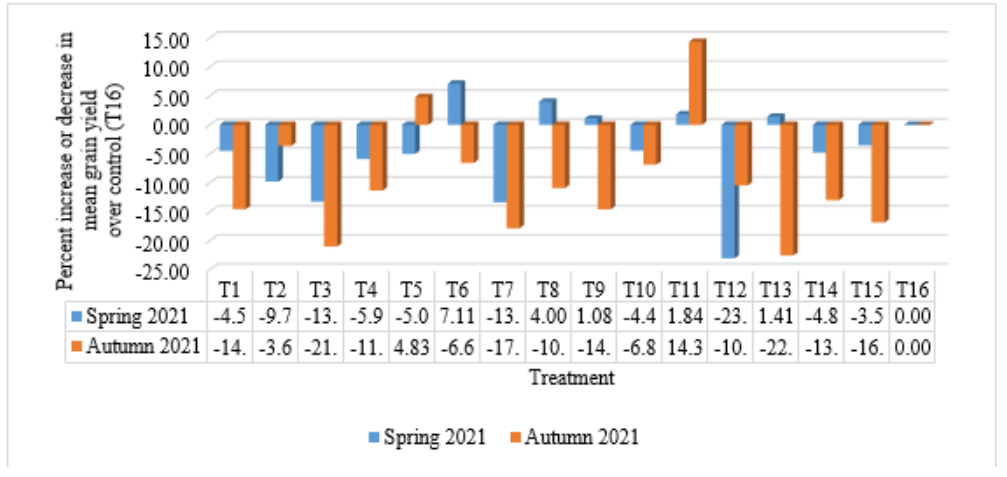

Figure 3: Percentage increase or decrease in mean grain yield over the untreated control (T16) spring and autumn 2021.

Figure 3. Percentage increase or decrease in mean grain yield over the untreated control (T16) spring and autumn 2021.

In general, all medicinal plant extracts and fungicidal treatment evaluated recorded significantly lower percent grain discolouration incidence as compared to the untreated control (Table 1 and 2, Figure 1). Out of which these treatment viz. Black sage (15%), Bale tree (15%); Madar plant (15%); Thick leaf thyme (15%); Neem (15%); Saaf 75 WP (300 g/ac.); Saaf 75 WP (500 g/ac.); Saaf 75 WP (7000 g/ac.); Saaf 75 WP (900 g/ac.); Rodazim 50 SC (300 ml/ac.); Glory 75 WG (600 g/ac.); Antracol 70 WP (500g/ac); Carbendazim 50 SC (300 g/ac.) and the positive check treatment Fugi-One at 300 ml/ac., showed reduction in the incidence of grain discolouration ranging from 33.54 to 75.06 percent over the four seasons in 2020 and 2021 as compared to the untreated control (Table 1,2 and Figure 1). Most of these treatments also showed positive influence in terms of growth parameters, yield parameters and grain yield as compared to the untreated control (Table 3-8, Figure 2 and 3) and therefore can be recommended for uses against the gain discolouration condition.

Discussion

Rice grain discoloration condition is becoming a serious threat to rice crop result in the lowering of the quality and quantity of rice being produced [7,9]. evaluated 12 aqueous plant extracts against seed born fungal pathogen associated with brinjal seeds, Solanum melongena L. and reported that all plant extracts significantly inhibited the tested fungi associated with brinjal seeds. These researchers also reported that the aqueous leaf extracts of Azadirachta indica and Calotropic procera significantly inhibit the growth of some seed borne fungi viz. Phomopsis vexans, Fusarium oxysporum, Aspergillus flavus, Aspergillus nigar, Curvularia lunata, Penicillium spp., with 4% and 5.3% seed infection as compared to the control with 66% seed infection and also enhanced the seed germination of brinjal seeds. Also [8], studied several plant extracts, fungicides and bio-agents against rice GD condition and reported that spraying of neem oil 80EC (3%) at flowering stage and ten days later reduced the grain discolouration from 21.60 to 11.45 per cent which was on par with carbendazim (250 g ha^{-1}) and also demonstrated significant increase in the grain yield compared to untreated control. Likewise in this present experiment similar findings were demonstrated when aqueous plant extracts of Black sage plant (Cordia curassavica) at 15% concentration, Bale tree (Aegle marmelos) at 15%; Madar plant (Calotropis gigantea, C. procera) at 15%; Thick leaf thyme(Thymus vulgaris) at 15% and Neem (Azadirachta indica) at 15% concentration, respectively were applied against the grain discolouration pathogens under field condition during first and second crop of 2020 and 2021 under Guyana condition. In alike manner, many other researchers around the world have evaluated many different fungicides for the control of the GD condition [7,10,11]. conducted similar study to this present research using four fungicides viz. Dithane M-45, Ridomil, Topsin-M and Carbendazim for the control of pathogens on with grain discolouration pathogens. The researcher reported that Dithane and Ridomil showed best control over mycelial growth of all isolated pathogens except F. moniliforme where Carbendazim was found the best followed by Topsin M, Dithane M-45 and Ridomil respectively. The researchers also reported that with the grain discoloration pathogen treated with both of these fungicides showed maximum germination and least seedling mortality. Likewise [11]. reported that treatment two foliar spray with Azoxystrobin 23SC (0.1%) performed better with lowest per cent incidence of grain discoloration and higher grain yields when the treatment was applied. Also [12], found carbendazim+mancozeb to give superior control over rest of the fungicides against discoloured rice grain and all other grain and yield attributes. Similarly, the results of these researchers were in agreement with the present research finding of this experiment where fungicides Saaf 75 WP (300 g/ac.); Rodazim 50 SC (300 ml/ac.); Glory 75 WG (600 g/ac.); Antracol 70 WP (500g/ac); Carbendazim 50 SC (300 g/ac.) and the positive check treatment Fugi-One at 300 ml/ac., showed higher reduction in the incidence of grain discolouration ranging from 33.54 to 75.06 percent over the four seasons in 2020 and 2021 as compared to the untreated control. Likewise, most of these treatments also showed positive influence in terms of growth parameters, yield parameters and grain yield as compared to the untreated control and therefore can be recommended for uses against as control of the gain discolouration condition. Additionally, the findings of this present study agreed fully with the results of [4]. When few of the same fungicides (Amistar Xtra 28 SC (Triazol, Estrobilurtina, Cyproconazol, Azoxystrobin) 1.5 mL L^{-1}; Glory 75 WG (Mancozeb+Azoxystrobin) at 3.0 g L^{-1}; Antracol 70WP (Propineb) at 5.0 g L^{-1}; and Carbendazim 50SC (Carbendazim 50%) at 1.5 mL L^{-1}) were evaluated against the grain discolouration condition. The researchers demonstrated and confirmed that these four fungicides demonstrated more than 50% reduction in the incidence of grain discolouration and reported greater number of filled grains, 1000 grain weight and grain yield compared to control.

Conclusion

It can be concluded from the research that these treatments with Black sage (15%), Bale tree (15%); Madar plant (15%); Thick leaf thyme (15%); Neem (15%); Saaf 75 WP (300-500 g/ac; Rodazim 50 SC (300 ml/ac.); Glory 75 WG (600 g/ac.); Antracol 70 WP (500g/ac); Carbendazim 50 SC (300 g/ac.) and Fugi-One at 300 ml/ac. demonstrated significant reduction in grain discolouration incidence and favorable influence in terms of plant growth, yield parameters and grain yield responses and therefore can be recommended as a protective treatment used for managing the grain discolouration conditions.

Author's Contributions

First author Rajendra Persaud design and carried out the experiments, analyzed the data and wrote the manuscript. All other authors provide technical advice, assisted with editing, moral support, read agree with the content of the manuscript.

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Disclosure Statement

There is no potential conflict of interest to declare.

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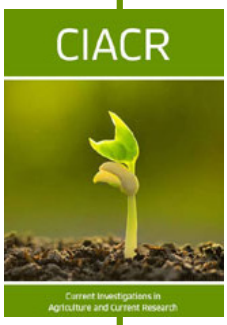

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